Autonomous Mobility Appliqué System(AMAS) JCTD

FY 12-13
Industry Day
(June 23, 2011)

Participants

- **COCOM Sponsor:** CENTCOM (Committed)
- **COCOM Co-Sponsor:** TRANSCOM(Proposed)
- **Lead Service**: US Army (Committed)
- **Oversight Executive:** OUSD(AT&L)DDRE/RFD/CS/Ellen Purdy (Committed)
- **Deputy Operational Manager:** CASCOM (Proposed)
- **Technical Manager:** TARDEC/Bernie Theisen (Committed)
- **Transition Manager:** RS JPO/Aaron Hart (Committed)
- **Other participants/partners:** CASCOM/MCCDC (Proposed Deputy OMs)

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US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA	**TACOM/TARDEC/RDECOM**
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Operational Problem Statement

- **Current forces are facing an operational environment based on uncertainty, anti access and aerial denial threat tactics. This environment increases Soldier risk due to interdiction of US Lines Of Communication via hit-and-run and standoff attacks. As a result, these threats increase responsibility of drivers and passengers to maintain situational awareness along unsecured routes.**

- **Current Operating Environment requires service members to conduct logistic resupplies and operational patrols on specified Main Supply routes.**
  - **Inherit vulnerabilities that are hard to mitigate**
  - **Enemy forces are adapting to our convoy operational doctrine,TTPS, and SOPs**
  - **Speed and distance predictable to execute attacks against the convoys.**
  - **Majority of IED detection is done through visual means**
    - **Small Window of detection and evasive action**

- **Convoys are encountering environmental weather conditions that impact convoy operations leading to reduced logistics through-put and vehicle damage from on and off road accidents.**
  - **Convoys have been cancelled**
    - **Impacting Logistic and Operational patrols**
  - **Accidents due to fatigue and poor visibility**
    - **Human Limitations Restrict Effectiveness of Force.**

- **Current forces are operating and navigating vehicles alone over prolonged periods of time.**
  - **Increasing potential for accidents**
  - **Degradation of Performance**
  - **Task Overload**

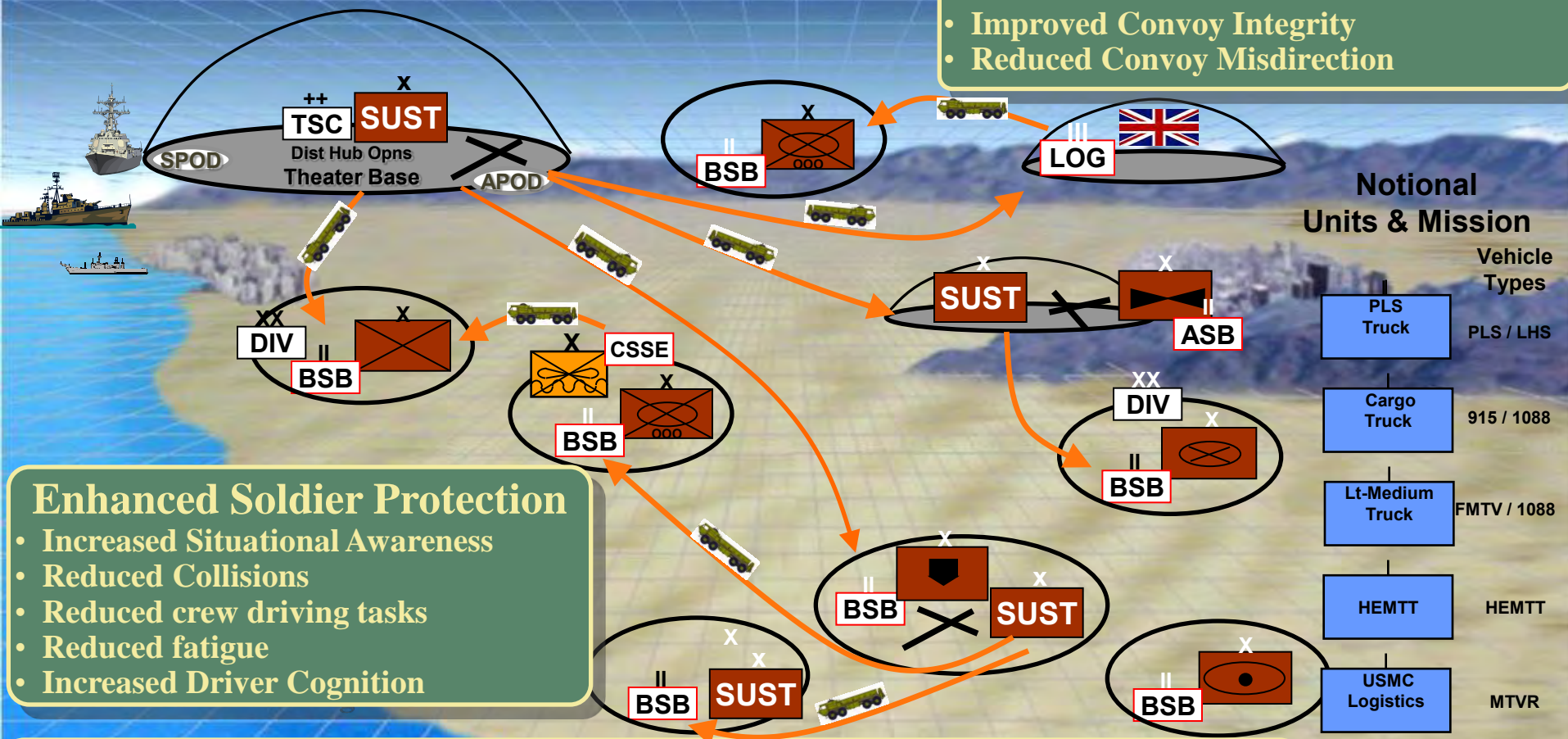**Increased Safety and Situational Awareness**

AMAS JCTD Technical Overview

- **Provide scalable autonomy in a single material solution agnostic of platform.**
  - Autonomy Kit
    - Autonomous Hardware and Sensors
  - By-wire Kit
    - Vehicle Specific Devices to Retrofit Current Tactical Vehicles
  - Common Interfaces
  - Common Framework
- **Scalable and flexible to address multiple task such as convoys, security, reconnaissance, sustainment, maneuver, maneuver support.**
- **Operational scenario using a secure mixed manned/unmanned platform convoy**
  - Year One Platforms - MTVR, LTV, HEMTT, M915 w/trailer
  - Year Two Platforms - PLS, HMMWV, MATV, FMTV w/trailer
  - Demonstrate increased vehicle safety with high op tempo in complex conditions
- **Conduct Technical Demos and Operational Demo (CONUS): Manned, Driver Assist, Remote Control, and Semi- Autonomous Leader/Follower.**

AMAS JCTD
Technical Approach

Year One

Integrate and Deploy Appliqué System:

- **Define and Integrate Appliqué System**
  - Autonomy Kit and Vehicle By-wire Kit
  - 2 Each MTVR, LTV, HEMTT, and M915 w/trailer.
- **Capability**
  - Driver Assist Functionality
  - Leader/Follower
- **Technical Deliverables**
  - Open Architecture and Interfaces
  - Standardized Metrics and Test Procedures w/ATEC
  - Framework for Validation of Realistic Requirements
  - LRU plug and play with limited adjustments
  - Fieldable Prototypes

Year Two

Increase levels of Autonomy and Expand Platforms:

- **Extend Kit Capability**
  - MATV, HMMWV, PLS, and FMTV w/trailer
- **Increase Capabilities in Autonomy Kit**
  - Enhanced Driver Assist
  - Limited Tele-Operations
  - Semi Autonomous Leader
- **Technical Deliverables**
  - Refine Year One Technical Deliverables
  - Scalable Autonomy
  - Self Calibrating LRUs
  - Improved Standardized Metrics and Test Procedures w/ATEC

Core Technologies
Technology Readiness Levels

Technology	Pre-JCTD	Post-JCTD
Vehicle Following (Cameras, LADAR, Comms)	6	9
Road / Lane following (improved & un-improved –Camera and LADAR)	6	8
Obstacle detection & avoidance	6	8
Communications Networking / Redundant Comms	6	8
Vehicle localization/Navigation (GPS/Non GPS) (Scene matching and Dead Reckoning)	6	9
Rear-End Collision Detection & Avoidance (Camera, RADAR, and LADAR)	8	9
Advanced Convoy Behaviors (Randomized Spacing and Speed, Splits and reformations)	6	7
Hardware/Software Framework	5	9
Integrated Driver Assist Technologies (Lame Departure, Collision Avoidance, Blind Zone warning, Brake Assist)	8	9

Open Standard Interfaces providing a foundation for Scalable Autonomy on Multiple Platforms/Variants

Capabilities of Scalable Autonomy

Level 1 Driver Assist	Level 2 Automated Driving	Level 3 Convoy Behaviors

• **Increase Situational Awareness**
 	
  • Environment and Surroundings
 	
  • Vehicle Capabilities and Configuration
 	
• **Improved Safety**
 	
  • Collision Warnings
 	
  • Lane Departure Warnings
 	
  • Tip Over Warnings
 	
  • Stability Control
 	
• **Reinforces Experienced drivers**
 	
• **Increase Capabilities of inexperienced Drivers**
	• **Active Intervention**
	
	  • Maintain Lane Control
	
	  • Tip-Over Prevention
	
	  • Collision avoidance and mitigation
	
	  • Stability Control
	
	• **Enables operator to focus on other convoy mission tasks while the vehicle safely operates itself.**
		• **Leader/Follower Capabilities**
		
		  • Increase Operational Tempo
		
		  • Run faster with disciplined spacing
		
		  • Increased convoy capacity though unmanned vehicles
		
		• **Increase throughput and efficiencies**
		
		• **Dynamic planning and re-planning**
		
		  • Flexibility in convoy composition and routing
		
		  • Re-acquire route after dispersal
		
		  • Re-plan route to alternate

AMAS JCTD Key Metrics

Capability	Tasks	Metric	Threshold	Objective
FOC 09-08 Soldier Support	Operator Interventions	Hours	TBD	TBD
Joint Land Ops	System Operation Range	Distance in meters	TBD	TBD
FOC 09-04 Operational Tempo	Speed	Kph	Max>40kph Min <5kph	Max>80kph Min<1kph
Joint Land Ops	Lateral Accuracy	Centimeters from lead path	100cm	50cm
Battle space Awareness	Obstacle Avoidance	Size in cm^3	TBD	TBD
FOC 07-01 Protect personnel	Situational Awareness	Sighting increase %	Target sighting increase 10%	Target sighting increase 20%
FOC 07-01 Protect personnel	Emergency braking	Operator Interventions per hour	1	0
Tactical behaviors	Multi-vehicle capability	Vehicles	4	20
Collaborative Operations	Leader / follower swap	Transition time in seconds	Less than 30 seconds	Less than 10 seconds
FOC 09-04 Operational Tempo	Controlling Platform	Distance from Operator	LOS 2 km	NLOS 1 km

Overall Demonstration Strategy & Plan

Schedule

- **Year One: Refinement and Integration**
  - Develop Common Appliqué Kit
  - Technical Demo Across Four Platform Variants
    - 2 Each MTVR, LTV, HEMTT, and M915 w/trailer.
  - Develop CONOPS / TTP and Finalize
- **Year Two: Operational Assessment and Transition**
  - Limited User Assessment
  - 2nd Technical Demonstrations
    - Four Additional Platforms for 16 Total
      - 2 Each MATV, HMMWV, PLS, and FMTV w/trailer
      - 2 Each MTVR, LTV, HEMTT, and M915 w/trailer.
  - Operational Utility Assessment
  - Final OUAR

Tech Demonstrations and Operation Assessment

- **Convoy Operations**
  - Limited MSRs/ASRs
  - Long / Short Haul Duration
  - High Speeds/Low Speeds
- **Operating conditions**
  - Visibility/Terrain
  - Threat/Extreme Climates
  - Night Movements
- **Full Spectrum Operations**

Transition Strategy

AMAS JCTD

Year One
- Contract Award
- 1st Tech Demo
- ATEC Reports

Year Two
- 2nd Tech Demo
- Operation Utility Assessment (OUA)
- ATEC Reports

Risk Reducers:
- Push AMAS Program Schedule to the Left
- Accelerate Technical Maturation
- Provide Open Architecture and Interfaces
- Standardized Metrics and Test Procedures
- Framework for Validation of Requirements
- Lessons Learned

AMAS CDD/CPD

Year One
- CDD Staffing

Year One
- AROC/JROC Approval
- POM Line Establishment
- MDD Preparation

Year Two
- MDD
- AOA Study Guidance
- Solicitation Preparation and Acquisition Strategy for CDD

OR
- Development of CPD

Year Three (Transition Year)
- Milestone B
- EMD Contract Award(s)

OR
- CPD AROC/JROC Approval

The AMAS JCTD will provide Risk Reduction to the AMAS Program

AMAS
Schedule and Cost

Major Tasks	Year 1				Year 2				COST ($k)
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	
Implementation Directive (ID) (60 Days after CDB)	▲								XXX
RFP/Contract negotiations (RTC Contract 105 days)	▬								XXX
Management Plan (60 Days After JCTD Start)		▲							XXX
Develop CONOPS / TTP and finalize		▬▬▬▬▬▬▬▬▬▬▬							XXX
Develop and update Design and Plans		▬▬							XXX
Integrate & Deploy Software/Hardware Components			▬▬▬▬▬						XXX
Install Integrated System				▬▬▬▬					XXX
Technical Demonstrations					▲		▲		XXX
ATEC Limited Safety Release and Assessment					▲		▲		XXX
Limited User Assessment						▲			XXX
Operator Training						▬▬			XXX
Operational Demonstration and Assessment							▲		XXX
Operational Utility Assessment Reports								▲	XXX
Note: Start is contingent on funding availability.							Program Total		XXX

Risk Management & Mitigation Approach

	Risk Factors (JCTD)	Risk Assessment	Mitigation Strategy	Expected Result
Operational	Identify units	Low	Work via OM, Service Staff to garner support and identify applicable units	Multiple units will be identified that can conduct demonstrations
	Soldier Assessment	Medium	Begin working early with ATEC to get limited Safety release	Limited Safety Release
Technical	Integrate hardware/software	Low	Identify installation points for Army/USMC Tactical Wheeled Vehicles	Create database of engineering drawings/specs that identify installation points and procedures for TWV
Cost	Cost of components	Low	Utilizing Commercial off the Shelf Components with Open Source Architecture and Interfaces	Mature components with higher reliability at lower cost
Funding	Funding level for the JCTD	High	Work with various agencies in the services to identify potential funding sources	Capture adequate funding to support JCTD
Schedule	Schedule – Demonstration and Assessments	Medium	Build upon outcomes of prior programs. Coordinating with ATEC to ensure timely testing deliverables.	OUA(S) scheduled to support concurrent development with acquisition documentation
Transition	Resource commitment to transition capability	Low	Develop detailed Plan and Technology Transition Agreement. Obtain resource commitment.	Transition is funded and immediately implemented following OD pending satisfactory OUA

JCTD Partnerships

Partner/Specific Organization	Status	Impact (Funding & Operational)
CENTCOM	On Board	**XXX**
TRANSCOM	In Discussions	**XXX**
CASCOM	On Board	**XXX**
RS JPO	On Board	**XXX**
JGRE	On Board	**XXX**
TARDEC	On Board	**XXX**
ARL	In Discussions	**XXX**
ONR (Navy Surface Warfare Center)	In Discussions	**XXX**
CECOM/CERDEC	In Discussions	**XXX**
SPAWAR	On Board	**XXX**
MCWL	In Discussions	**XXX**
ATEC	In Discussions	**XXX**
PEO Land Systems USMC	In Discussions	**XXX**

Summary

- Technical idea: Provide scalable autonomy in a single material solution agnostic of platform. The material solution would provide a Autonomous Mobility Appliqué System (AMAS) comprised of a scalable Autonomy Kit and a Vehicle By-wire kit. The Autonomy kit would provide scalable autonomy ranging from Driver Assist functionality through autonomous behaviors. The Vehicle By-wire kit would provide the actuation and interface for the Autonomy kit's capabilities.

- Demonstration Approach:
  - 2 Technical Demonstration 4th Qtr First Year/2nd Qtr Second Year
  - 1 Limited User Assessment 1st Qtr Second Year
  - 1 Operation Utility Assessment 3rd Qtr Second Year

- Deliverables:
  - Year 1: AMAS w/common interfaces defined and driver assist capabilities.
  - Year 2: AMAS applied to additional platforms and additional levels of autonomy.
            Potential CPD
- Transition: FY14 with Milestone B and EMD Contract Award(s) OR CPD AROC/JROC Approval

- Recommendation: Approve $ _____ Commitment of OSD/RFD Funds:

RFD Assessment Matrix

Project: (Name of JCTD)	RFD Assessment
Relevance	Go/No-Go
Speed to Delivery	Go/No-Go
Executability	Go/No-Go
Technology	Green/Yellow/Red
Transition	Green/Yellow/Red
Management	Green/Yellow/Red
Funding	Green/Yellow/Red
ASD(R&E) Checklist	
- Does it fit DoD Mission Space	Yes/No
- Does it fit ASD(R&E) Imperatives	Yes/No
- Does it fit RFD Mission	Yes/No
- Is it Free of Operational Activity	Yes/No
- Is it Free of Title 50 Activity	Yes/No
- Is it R&D or O&M Funded	Yes/No
- Are Success Criteria Clearly Defined	Yes/No

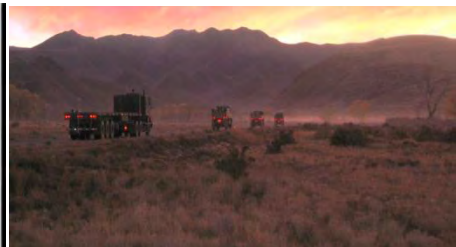**Note: Assessment matrix should be developed in conjunction with RFD and updated as a result of CNB**

Back-ups

AMAS JCTD

Operational Problem: The current and future force will face an operational environment based on uncertainty, anti access and aerial denial threat tactics. This environment increases Soldier risk due to interdiction of US Lines Of Communication via hit-and-run and standoff attacks. As a result, these threats increase responsibility of drivers and passengers to maintain situational awareness along unsecured routes.

Specifics:

Year 1 Integrate and Deploy Appliqué System
Operation: Convoy w/2 Each MTVR, LTV, HEMTT, and M915 w/trailer.
Capability: Driver Assist, Leader/Follower
Technical Deliverables: Open Architecture and Interfaces, Standardized Metrics and Test Procedures, Framework for Validation of Realistic Requirements, LRU plug and play with Limited Adjustments

Year 2 Increase levels of Autonomy and Expand Platforms
Operation: Extend to MATV, HMMWV, PLS, and FMTV w/trailer
Capability: Enhanced Driver Assist, Limited Tele-Operations
Semi Autonomous Leader
Technical Deliverables: Scalable Autonomy, Self Calibrating LRUs, Improved Standardized Metrics and Test Procedures, Conduct operational utility assessment

Requirement:

- Appliqué for current Light, Medium and Heavy Wheeled vehicles
- Levels of autonomy including Waypoint Navigation, Leader/Follower, Supervised Autonomy, Driver Assist, Remote Control.
- Behaviors to include Collision Avoidance, Lane Departure, ODOA, Vehicle Tracking, Road/Lane Following, Semi Autonomous Convoying, Adaptive Cruise Control
- Operate within CREW Environment and Spectrum
- Operate in Day, Night (black out), inclement weather, dust and limited visibility environments
- Increased safety, situational awareness

Competing Technology:

- CAST, CAMS, ANS, MARTI, Blind driver, TerraMax

Transition: Transition Manager – RS JPO

FY13 MDD/AOA Study Guidance
    Solicitation Preparation and Acquisition Strategy for CDD
        OR
    Development of CPD
FY14 (Transition Year)
    • Milestone B
    • EMD Contract Award(s)
        OR
    • CPD AROC/JROC Approval

Funding:

ORG	Year One	Year Two	TOTAL
JCTD Participants	XXX	XXX	XXX
OSD/RFD	XXX	XXX	XXX
		TOTAL	XXX

AMAS JCTD Key Metrics

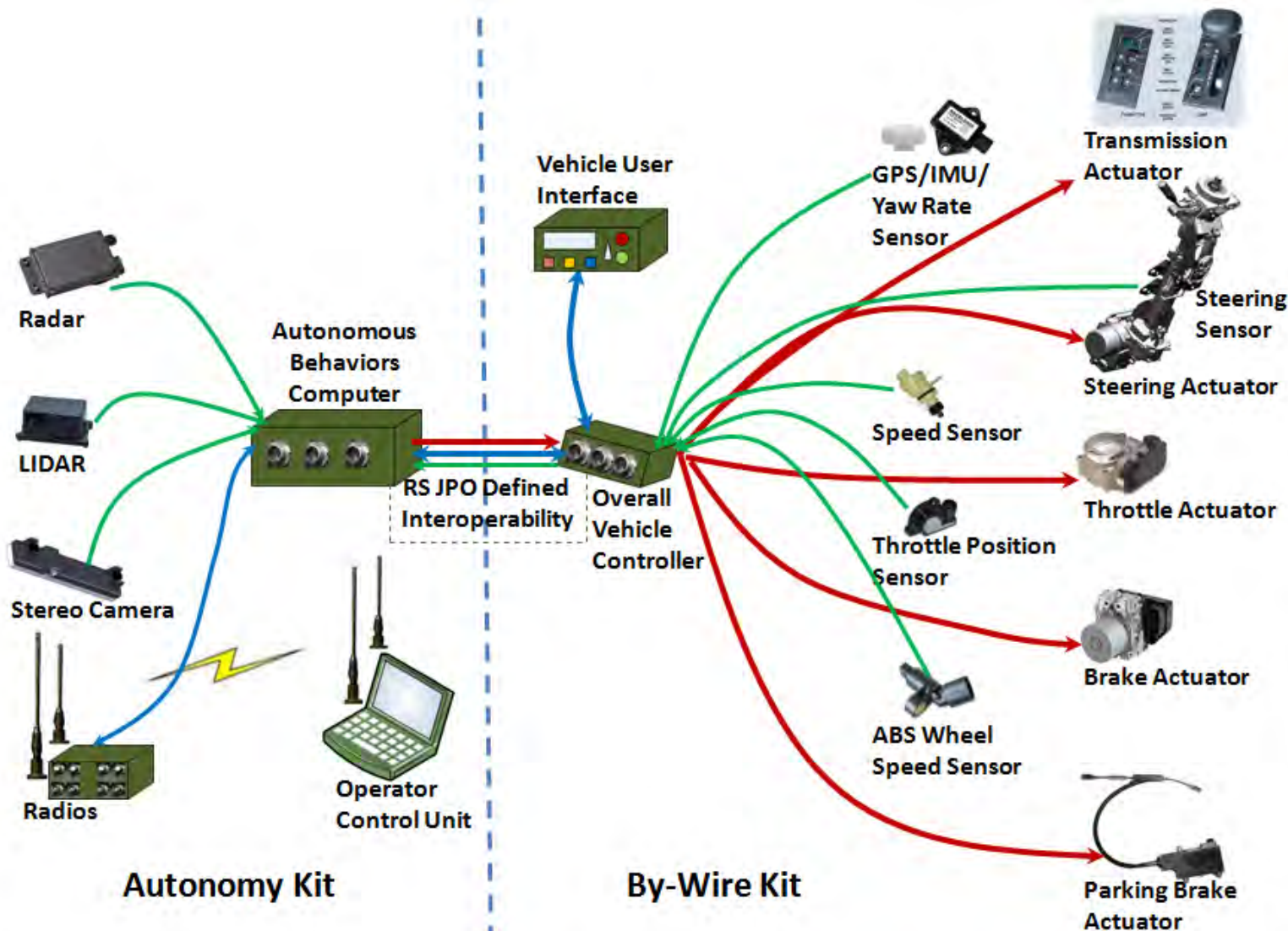| Capability	Tasks	Metric	Threshold	Objective
FOC 07-01 Protect personnel	**Collision Warning**	**Type 1 Error(False Positive)** **Type 2 Error(False Negative)**	**1/1000 miles** **5% Failures**	**None** **None**
FOC 07-01 Protect personnel	**Lane Departure** **Paved Roads**	**Type 1 Error(False Positive)** **Type 2 Error(False Negative)**	**1/1000 miles** **5% Failures**	**Unpaved Roads**
FOC 07-01 Protect personnel	**Curve Speed**	**Type 1 Error(False Positive)** **Type 2 Error(False Negative)**	**1/1000 miles** **5% Failures**	**None** **None**
Joint Land Ops	**System Op Range**	**Distance in meters**	**100 meters**	**1,000 meters**
FOC 09-04 Operational Tempo	**Speed**	**Kph**	**10kph**	**80kph**
FOC 09-04 Operational Tempo	**Video**	**Bandwidth**	**1MBS**	**100kBS**
FOC 09-04 Operational Tempo	**Controlling Platform**	**Distance from Operator**	**LOS** **2 km**	**NLOS** **1 km**

Desired Capabilities

- **Facilitate increased convoy protection and safety**
- **Maximize Truck Capability**
  - **Human Limitations minimized**
- **Improve Situational Awareness**
  - **Focus concentration on a single set of operations**
- **Increase Safety and Security**
  - **Disciplined speeds, proper distance between vehicles**
  - **Accident / Rollover Avoidance**
  - **Improved operations in no/limited visibility conditions**
- **Increase operational efficiency and effectiveness to support distribution operations**
  - **Reduces impact of human error**
- **Scalable Levels of Autonomy**
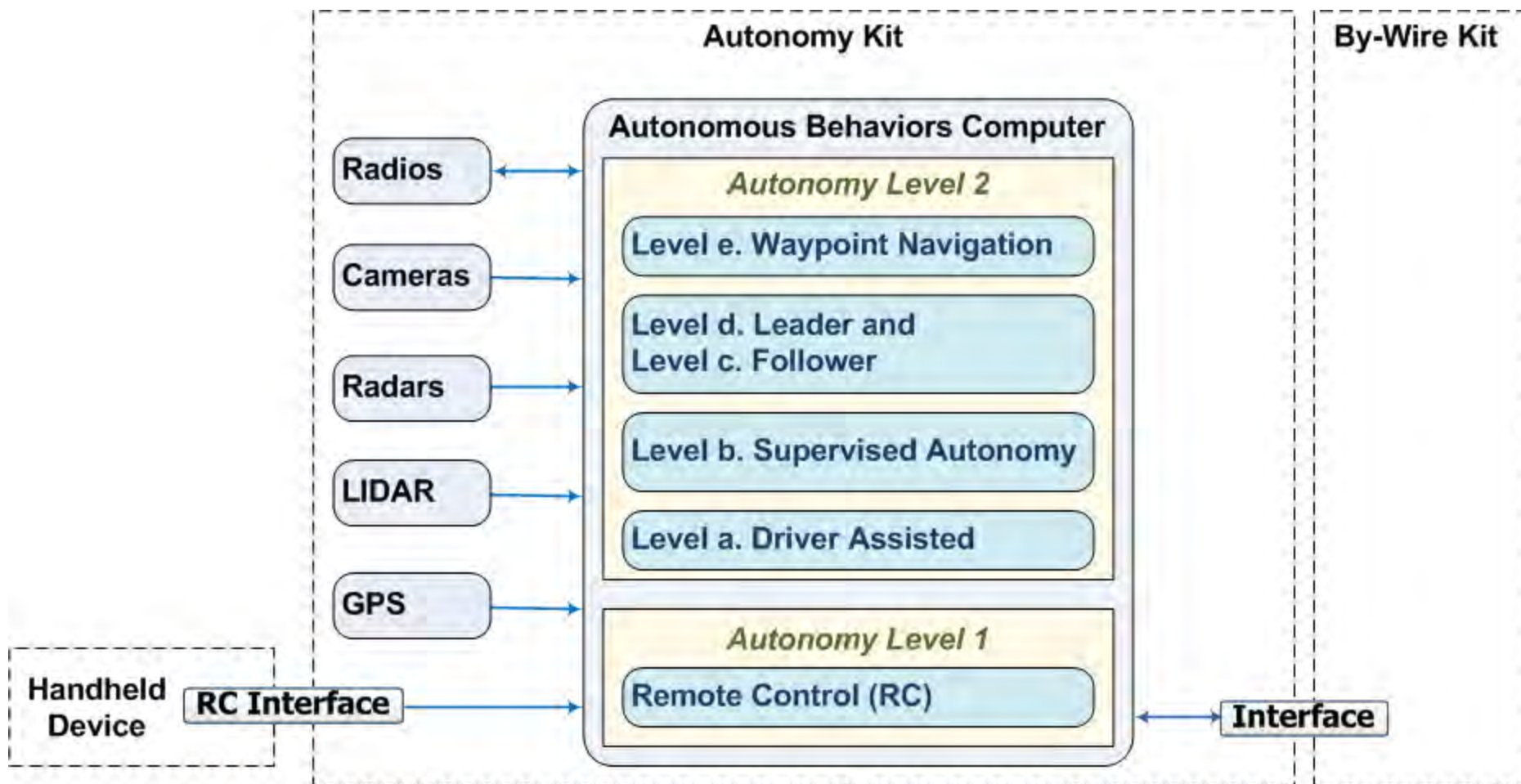- **Retrofit Existing Platforms**
- **Modularity and Interoperability**

Notional Autonomous Mobility Appliqué System (AMAS)

Notional Autonomy Kit